MINI-GRID RENEWABLES POWER FLOW STUDY

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Mini-Grid Study Scope

- Area - 12mi x 11 Mi area in Chino Basin
- Renewables Studied
  - Non-residential BI-PV
  - Dairy Waste and Waste Water Biogas
  - Landfill Bioreactor Biogas
- Expected, High and Low Penetration in 2007 and 2012
- Perform Power Flow Analysis to Determine Potential Local T&D Impacts & Value

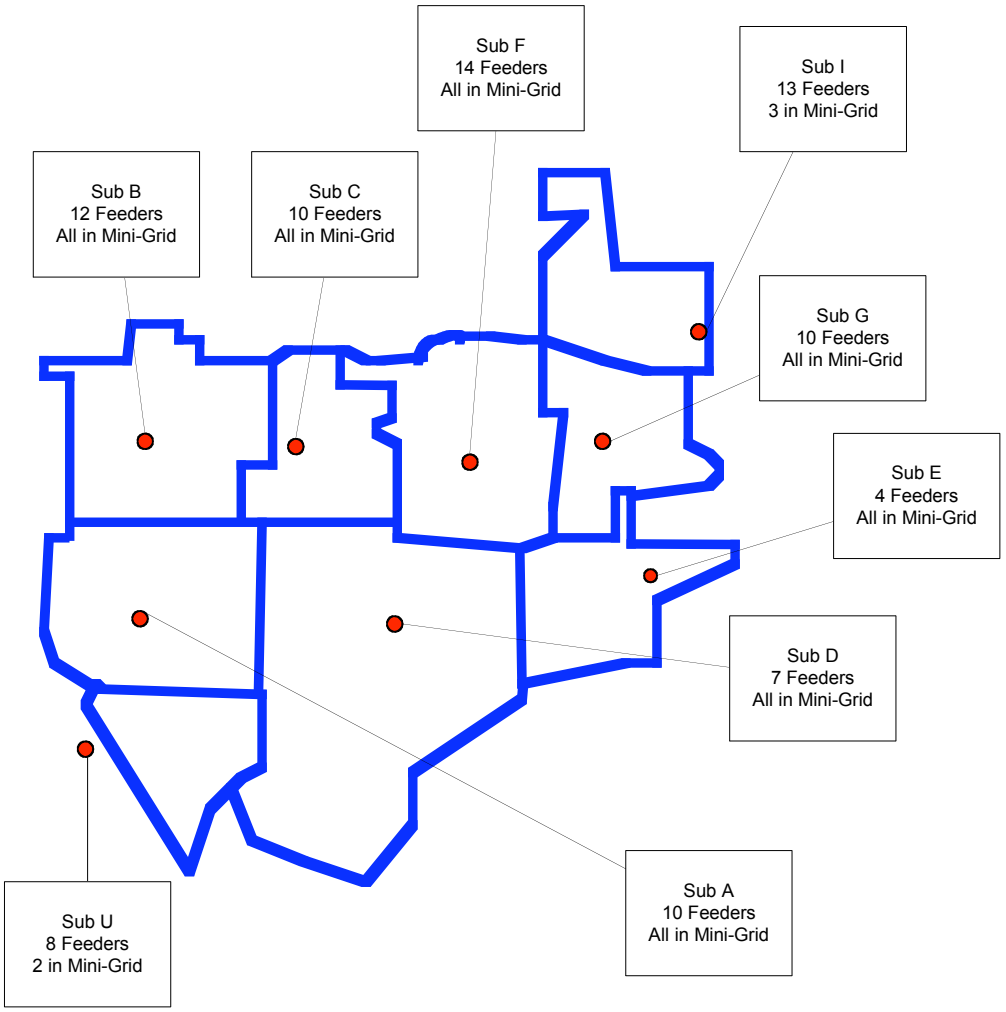
Mini-Grid T&D Data Collection

- Obtain local SCE 66/12 kV substation and 12 kV feeder configuration, ratings, conductor size, projected peak Year 2003 substation and feeder loads from SCE
- Develop representative electrical parameters
- Lay out Chino mini-grid electrical database
- Add local 66kV Subtransmission configuration electrical data, local generation data and interconnection point
- Insert local mini-grid model in WECC transmission PSLF load flow case

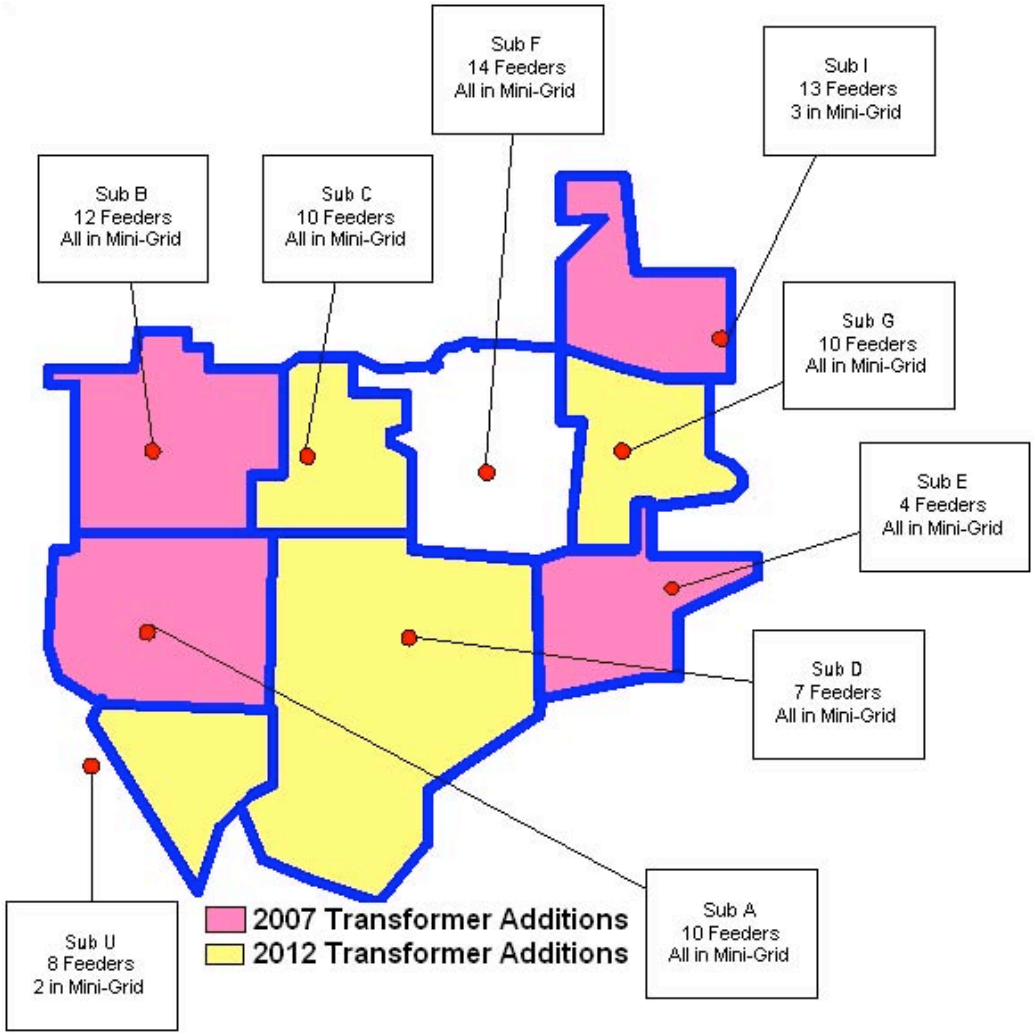
Mini-Grid T&D Model Development

- 9 – 66/12 kV Substations
- 72 – 12 kV feeders
- Mini-grid 2003 peak load about 565 MVA
- Expand to 2007 assuming peak load growth of 3%/yr.
- And from 2007 to 2012 at 1.7%/yr.
- Add transformer and feeder capacity as needed
- Determine appropriate light load case

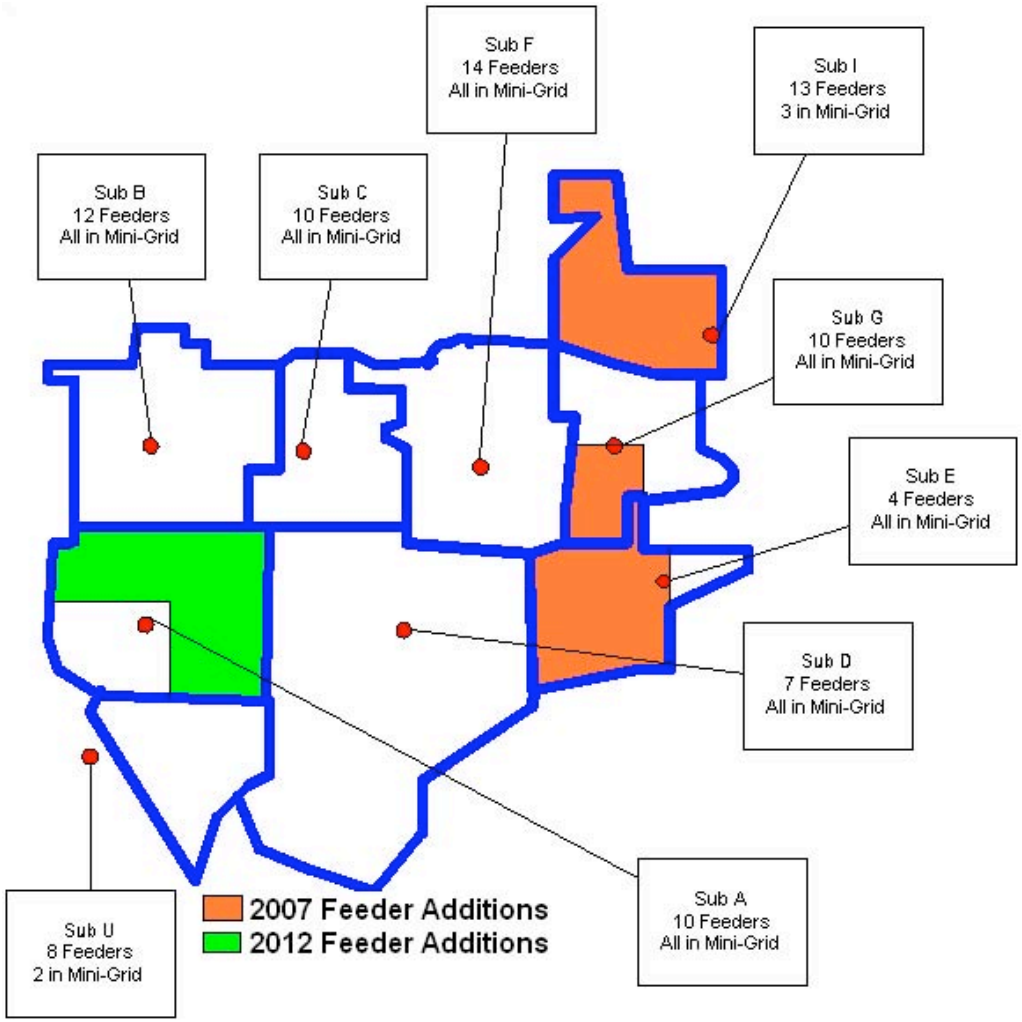
Mini-Grid Overview



Transformer Additions



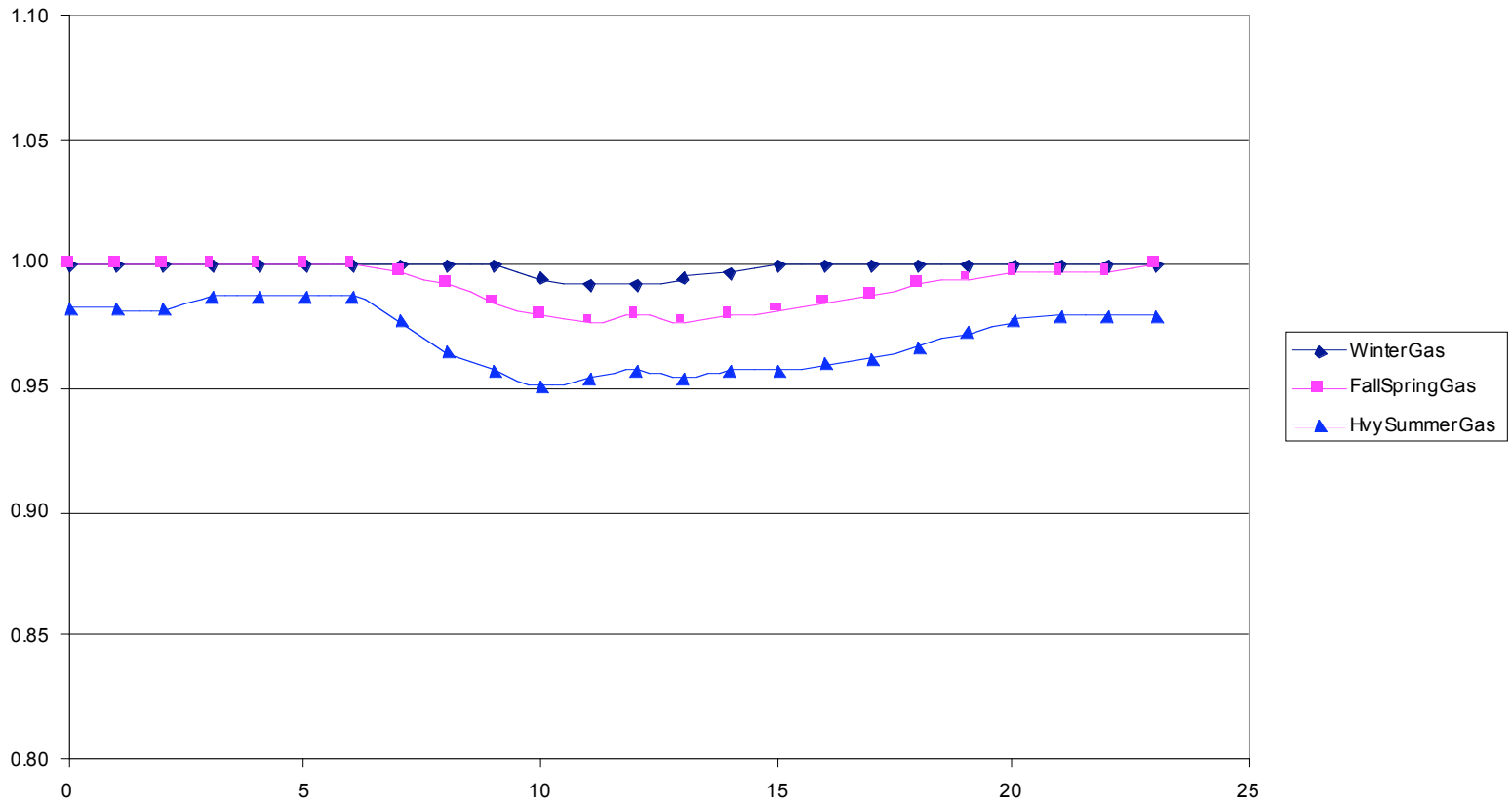
Feeder Additions



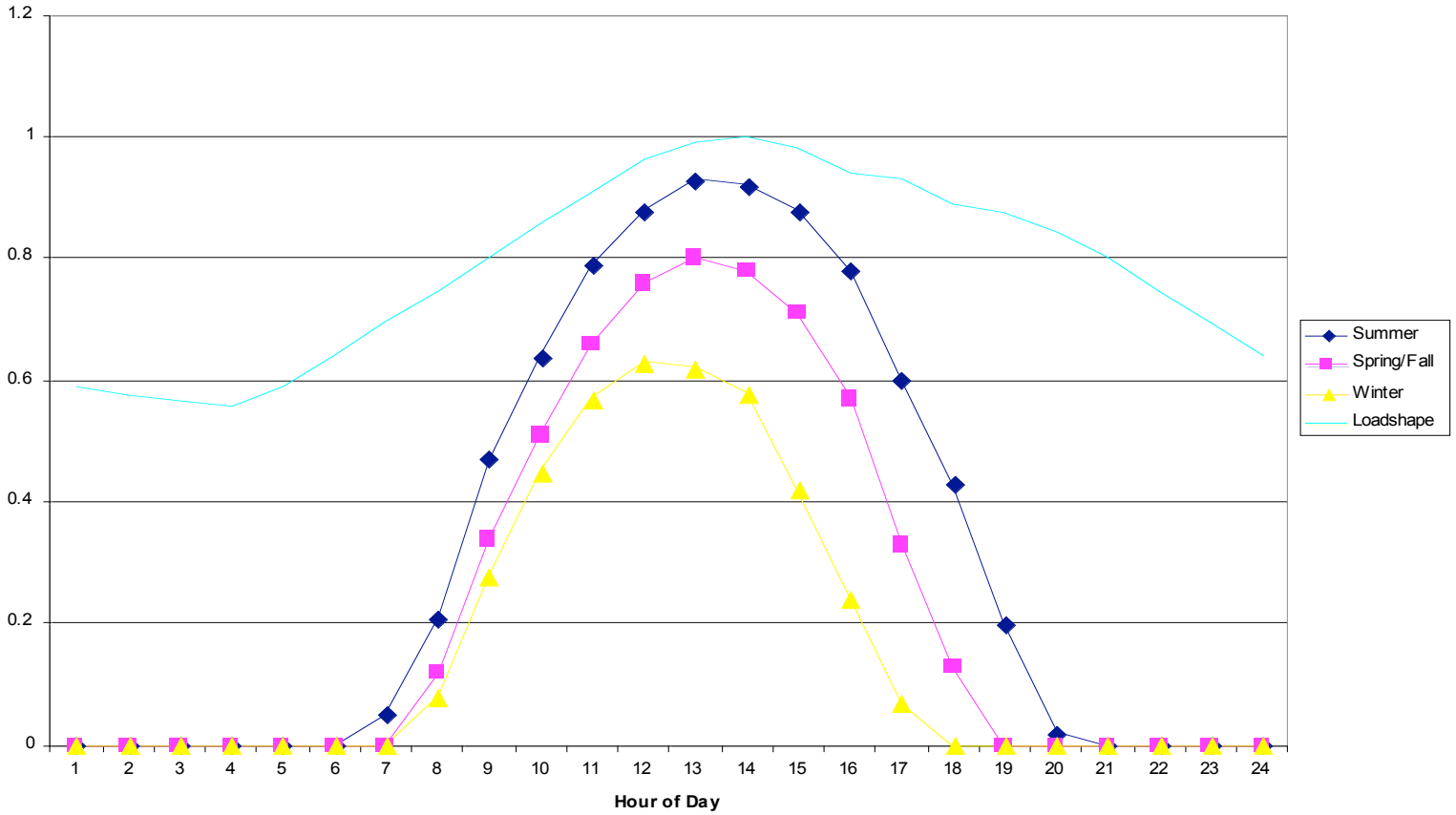
Expected, High and Low Renewable Penetration

	2007			2012		
	BI-PV (MW)	Biogas (MW)	Total (MW)	BI-PV (MW)	Biogas (MW)	Total (MW)
Penetration Scenario						
Expected	3.8	6.2	10.0	19.5	8.3	27.8
High	17.7	11.7	29.4	39.0	15.1	54.1
Low	1.4	4.8	6.2	2.1	5.4	7.5
Mini-Grid Peak Load			621			672

Seasonal Biogas Output Profile



Seasonal BI-PV Output Profile



DG Distribution System Impacts

- Site-Specific or Location-Specific
- Power Flow Reduction
- Loss Reduction
- Voltage Regulation
- Reliability
- Flicker
- Reverse Power Flow

Potential Transformer MVA Reduction 2007 Peak

Sub	MVA	MVA	MVA Reduction		
Bank	Rating	BaseCase	Expected	High	Low
A	117	90.2	0.3	1.8	0.1
B	138	103.8	0.4	2.1	0.2
C	89	87.1	0.6	2.8	0.2
D	56	53.6	1.2	5.3	0.7
E	71	38.7	0.2	1.1	0.1
F	138	124.3	6.2	11.0	4.7
G	94	90.5	0.6	2.9	0.2
U	70	64.8	0.2	1.3	0.0
I	165	130.3	0.4	1.3	0.2

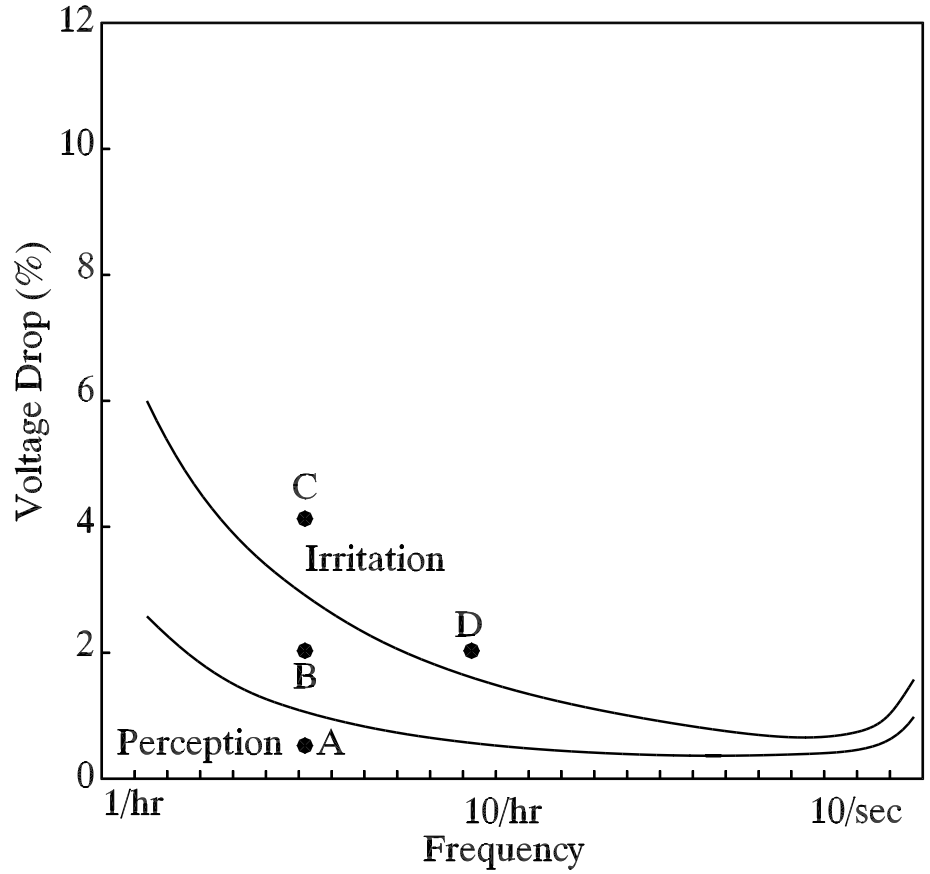
Potential Transformer MVA Reduction 2012 Peak

Sub	MVA	MVA	MVA Reduction		
Bank	Rating	BaseCase	Expected	High	Low
A	117	97.1	2.0	4.0	0.2
B	138	109.6	2.3	4.5	0.2
C	125	94.6	3.0	6.1	0.3
D	92	58.3	2.8	7.4	1.1
E	71	42.3	1.3	2.5	0.2
F	138	135.7	10.9	17.8	4.9
G	130	98.4	3.2	6.5	0.4
U	106	70.4	0.7	1.9	0.1
I	165	142.0	1.7	3.5	0.5

Potential Mini-Grid Loss Reduction

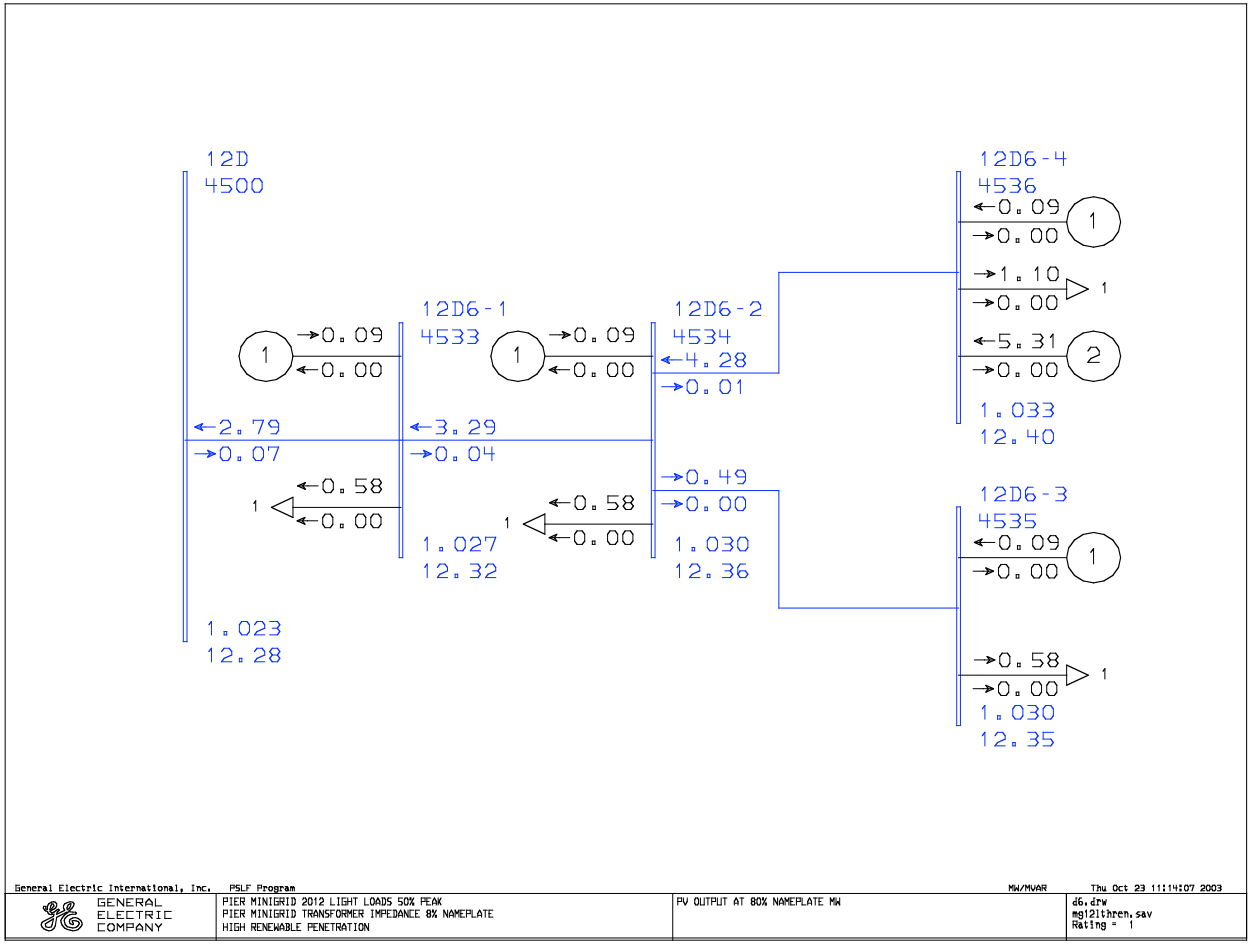
	Base Case Bus Load		Renewable Penetration		
	Mini-Grid	Mini-Grid	Loss Reduction (MW)		
Case	Load (MW)	Losses (MW)	Expected	High	Low
2007 Peak	621	17.81	0.41	1.23	0.24
2007 Light	311	4.67	0.16	0.47	0.10
2012 Peak	672	20.69	1.39	2.54	0.36
2012 Light	336	5.34	0.53	0.92	0.15

Potential Flicker



Voltage Flicker Curve

Example Reverse Power Flow



Distribution Facility Cost Estimates

	Total	Annual
	CI	Fix Chg
2007 Distribution Additions	**($1000)**	**($1000)**
4- 28 MVA Transformers	5,965	895
2-4 mi Underground Feeders	4,727	709
1-3 mi Underground Feeder	1,773	266
1-3.5 mi Underground Feeder	2,068	310
1-1.3 mi Overhead Feeder	329	49
	Total	**Annual**
	CI	**Fix Chg**
2012 Distribution Additions	**($1000)**	**($1000)**
4- 28 MVA Transformers	6,915	1,037
2-4 mi Underground Feeders	5,480	822

Potential T&D Benefits - $/kW

Potential Year 2007 Benefit in 2007 Dollars	**High**
Defer Sub E Transformer Addition	130
Defer 2-4 mi.Sub E Feeder Additions	560
Defer 1-3 mi.Sub G Feeder Addition	200
Defer 1-3.5 mi.Sub I Feeder Addition	160
Potential Year 2012 Benefit in 2012 Dollars	
Defer Sub C Transformer Addition	100
Defer Sub D Transformer Addition	130
Defer Sub G Transformer Addition	95
Defer Sub U Transformer Addition	90
Defer 2-4 mi.Sub A Feeder Additions	820

Chino Basin Renewables Mini-grid Power Flow Study Results

- Significant distribution system benefits: > $800/kW
- High DG penetration of 6 to 8 MW expected within 5 to 10 years on some feeders
- Could experience twice present allowable DG penetration levels on urban distribution feeders
- Similar results can be expected for other urban distribution systems in CA
- Detailed high DG penetration distribution facilities study recommended by TAC at Project 1.1 CPR Meeting

Next Step - Detailed Facilities Study

- High DG penetration
- Detailed interconnection study
  - Relaying requirements
  - Integrated voltage control
  - Reactive power scheduling
  - Short circuit duty impacts
- Dynamic study
  - Transient response to nearby disturbances
  - Ride through capability of DG